Fig. 1

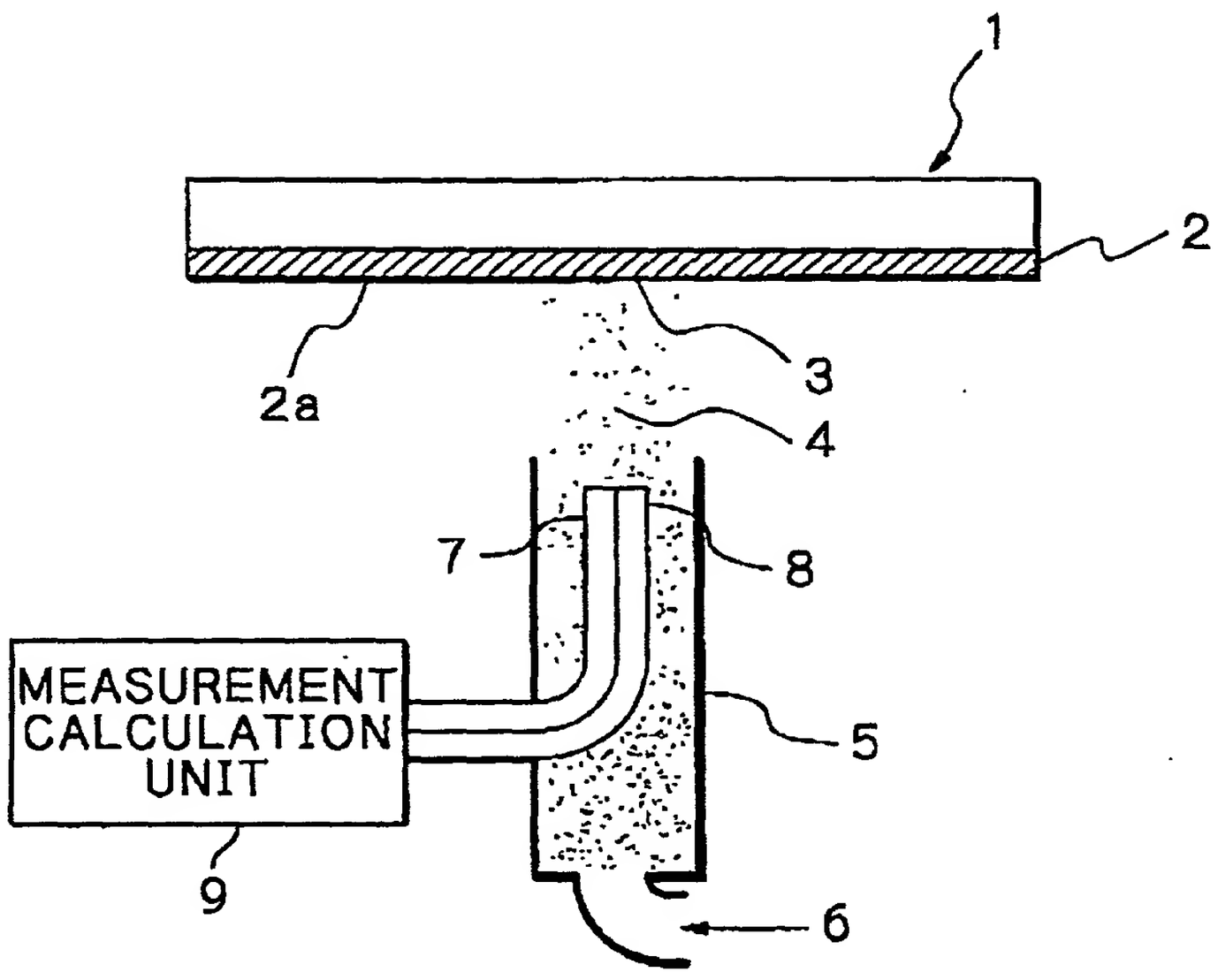

Fig. 2

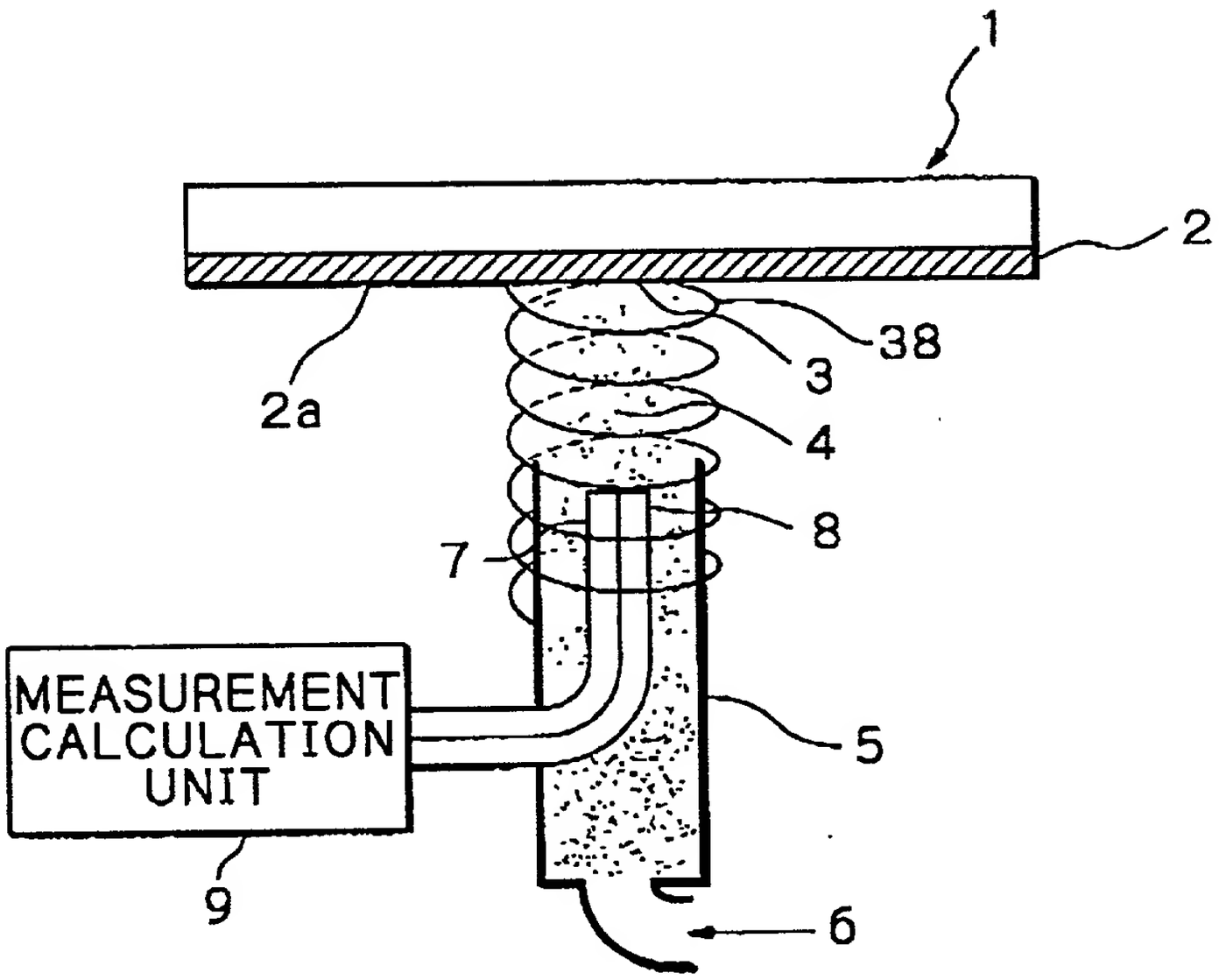

Fig. 3

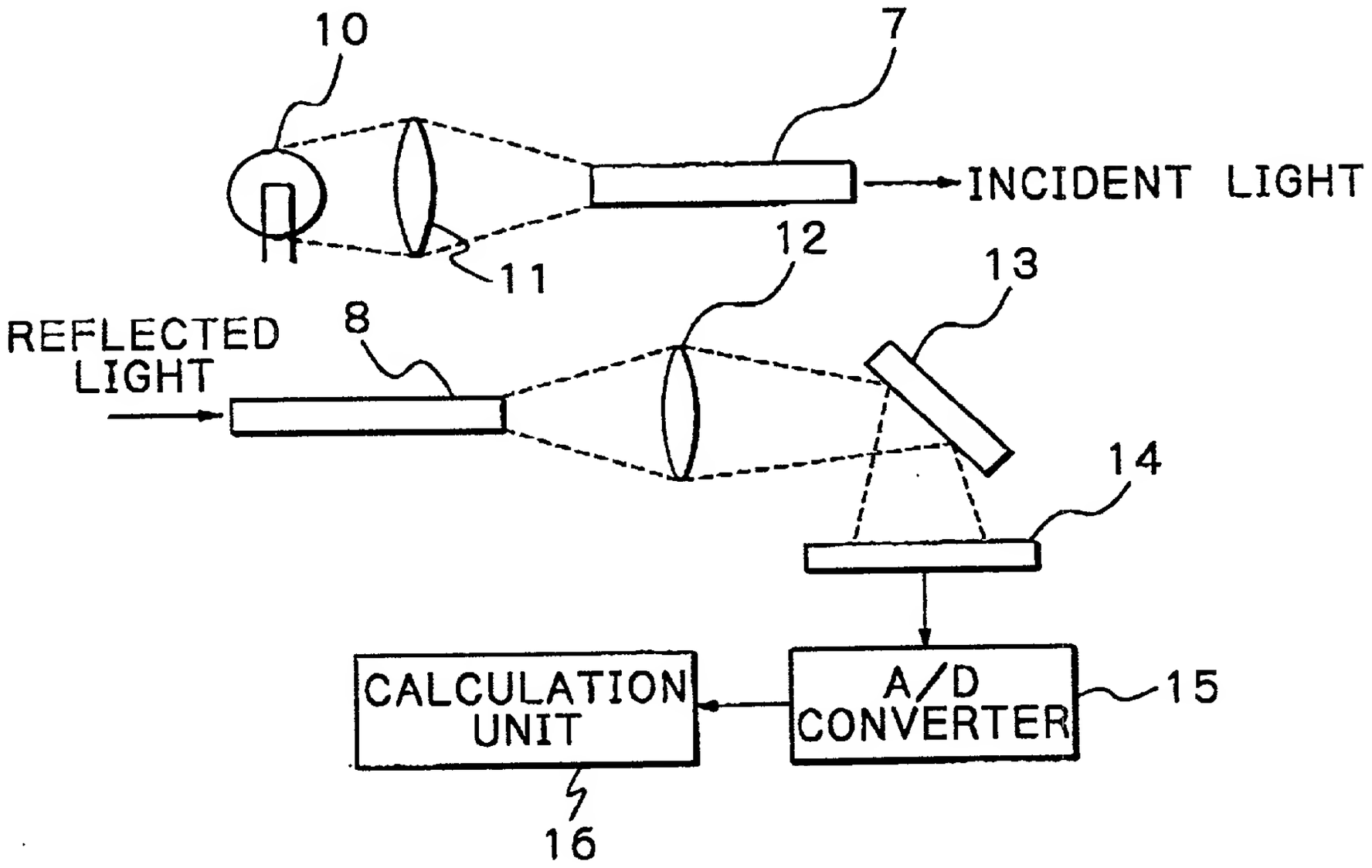
10
7
INCIDENT LIGHT
12
11
13
REFLECTED LIGHT
8
14
CALCULATION UNIT
A/D CONVERTER
15
16

Fig. 4

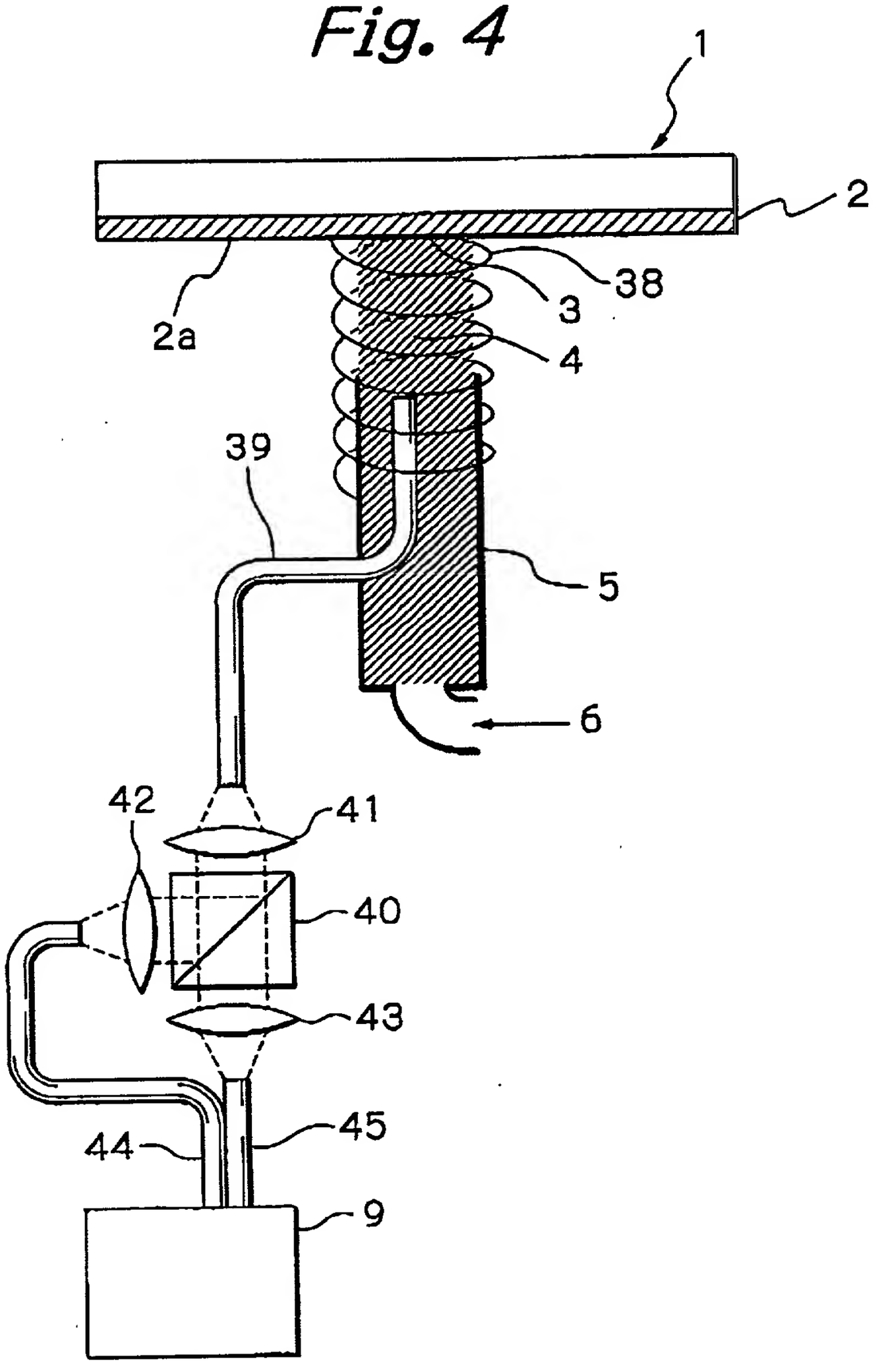

Fig. 5

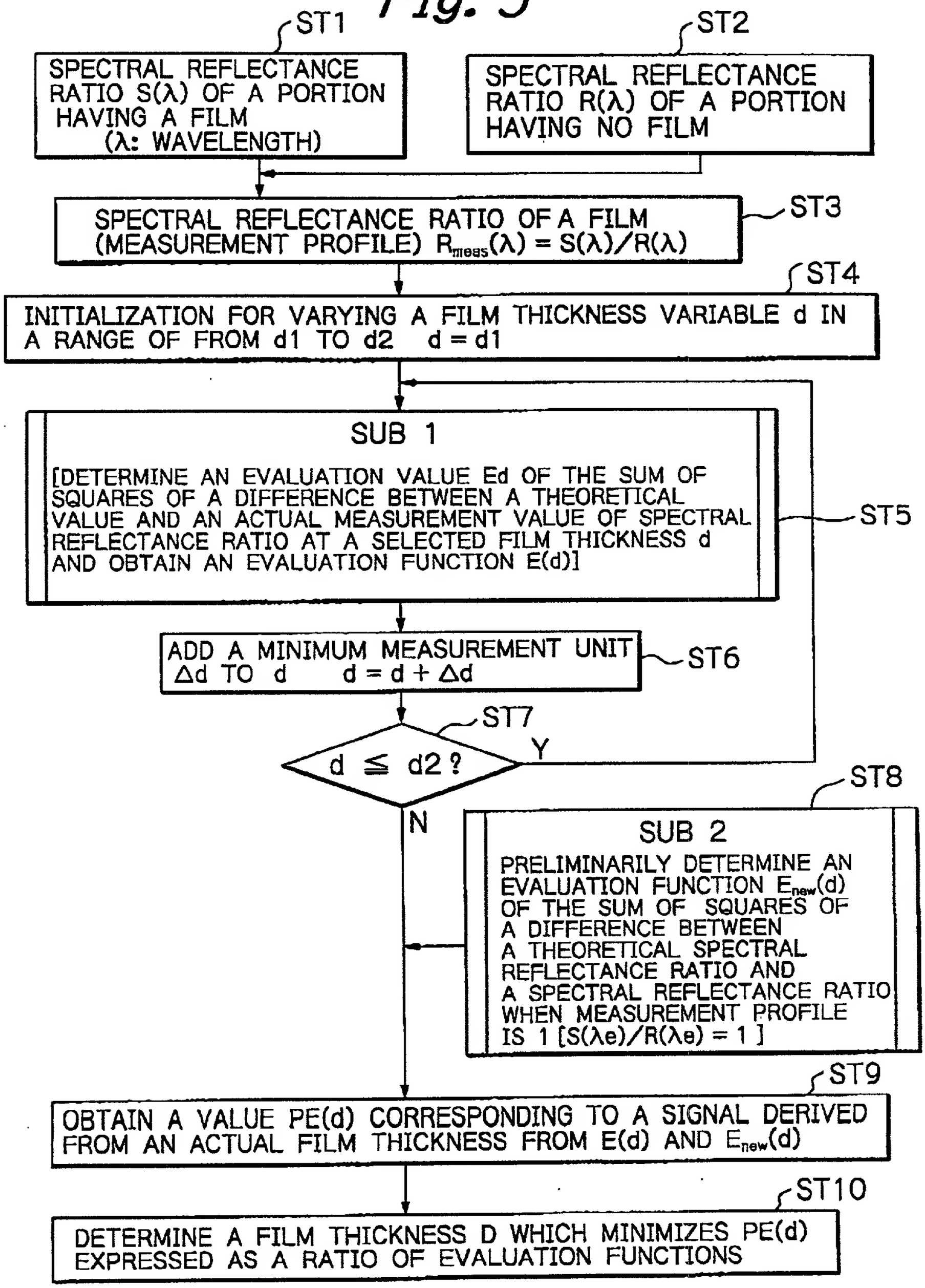
ST1
SPECTRAL REFLECTANCE RATIO S(λ) OF A PORTION HAVING A FILM (λ: WAVELENGTH)
ST2
SPECTRAL REFLECTANCE RATIO R(λ) OF A PORTION HAVING NO FILM
SPECTRAL REFLECTANCE RATIO OF A FILM (MEASUREMENT PROFILE) $R_{meas}(\lambda) = S(\lambda)/R(\lambda)$
ST3
ST4
INITIALIZATION FOR VARYING A FILM THICKNESS VARIABLE d IN A RANGE OF FROM d1 TO d2 d = d1
SUB 1
[DETERMINE AN EVALUATION VALUE Ed OF THE SUM OF SQUARES OF A DIFFERENCE BETWEEN A THEORETICAL VALUE AND AN ACTUAL MEASUREMENT VALUE OF SPECTRAL REFLECTANCE RATIO AT A SELECTED FILM THICKNESS d AND OBTAIN AN EVALUATION FUNCTION E(d)]
ST5
ADD A MINIMUM MEASUREMENT UNIT Δd TO d d = d + Δd
ST6
ST7
d ≦ d2 ?
Y
N
ST8
SUB 2
PRELIMINARILY DETERMINE AN EVALUATION FUNCTION $E_{new}(d)$ OF THE SUM OF SQUARES OF A DIFFERENCE BETWEEN A THEORETICAL SPECTRAL REFLECTANCE RATIO AND A SPECTRAL REFLECTANCE RATIO WHEN MEASUREMENT PROFILE IS 1 [S(λe)/R(λe) = 1]
ST9
OBTAIN A VALUE PE(d) CORRESPONDING TO A SIGNAL DERIVED FROM AN ACTUAL FILM THICKNESS FROM E(d) AND $E_{new}(d)$
ST10
DETERMINE A FILM THICKNESS D WHICH MINIMIZES PE(d) EXPRESSED AS A RATIO OF EVALUATION FUNCTIONS

Fig. 6

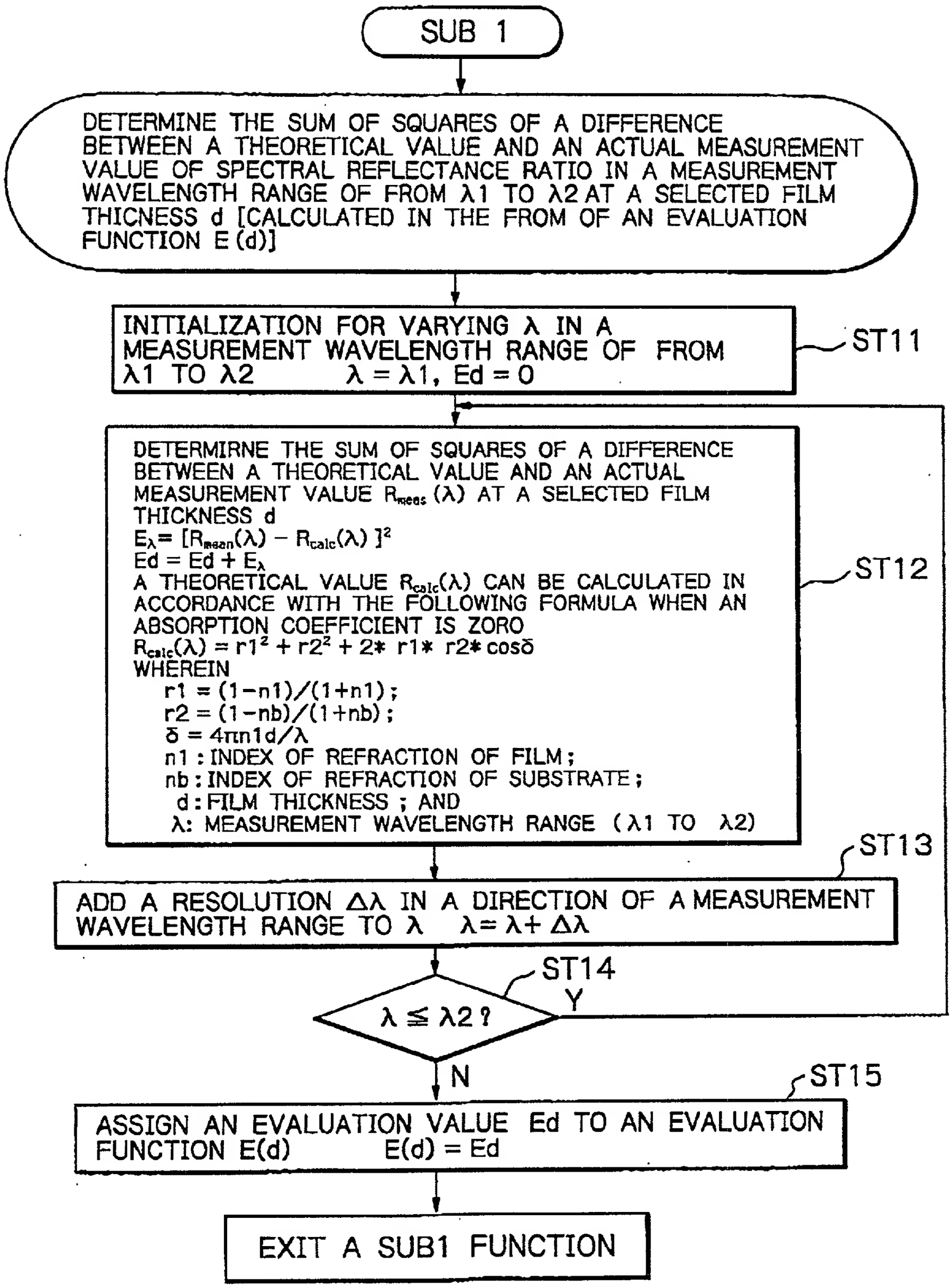
SUB 1
DETERMINE THE SUM OF SQUARES OF A DIFFERENCE BETWEEN A THEORETICAL VALUE AND AN ACTUAL MEASUREMENT VALUE OF SPECTRAL REFLECTANCE RATIO IN A MEASUREMENT WAVELENGTH RANGE OF FROM λ1 TO λ2 AT A SELECTED FILM THICNESS d [CALCULATED IN THE FROM OF AN EVALUATION FUNCTION E(d)]
INITIALIZATION FOR VARYING λ IN A MEASUREMENT WAVELENGTH RANGE OF FROM λ1 TO λ2 λ = λ1, Ed = 0
ST11
DETERMIRNE THE SUM OF SQUARES OF A DIFFERENCE BETWEEN A THEORETICAL VALUE AND AN ACTUAL MEASUREMENT VALUE $R_{meas}(\lambda)$ AT A SELECTED FILM THICKNESS d
$E_\lambda = [R_{mean}(\lambda) - R_{calc}(\lambda)]^2$
$Ed = Ed + E_\lambda$
A THEORETICAL VALUE $R_{calc}(\lambda)$ CAN BE CALCULATED IN ACCORDANCE WITH THE FOLLOWING FORMULA WHEN AN ABSORPTION COEFFICIENT IS ZORO
$R_{calc}(\lambda) = r1^2 + r2^2 + 2 * r1 * r2 * \cos\delta$
WHEREIN
r1 = (1−n1)/(1+n1);
r2 = (1−nb)/(1+nb);
δ = 4πn1d/λ
n1 : INDEX OF REFRACTION OF FILM;
nb : INDEX OF REFRACTION OF SUBSTRATE;
d : FILM THICKNESS ; AND
λ: MEASUREMENT WAVELENGTH RANGE (λ1 TO λ2)
ST12
ST13
ADD A RESOLUTION Δλ IN A DIRECTION OF A MEASUREMENT WAVELENGTH RANGE TO λ λ = λ + Δλ
ST14
λ ≦ λ2 ?
Y
N
ST15
ASSIGN AN EVALUATION VALUE Ed TO AN EVALUATION FUNCTION E(d) E(d) = Ed
EXIT A SUB1 FUNCTION

Fig. 7

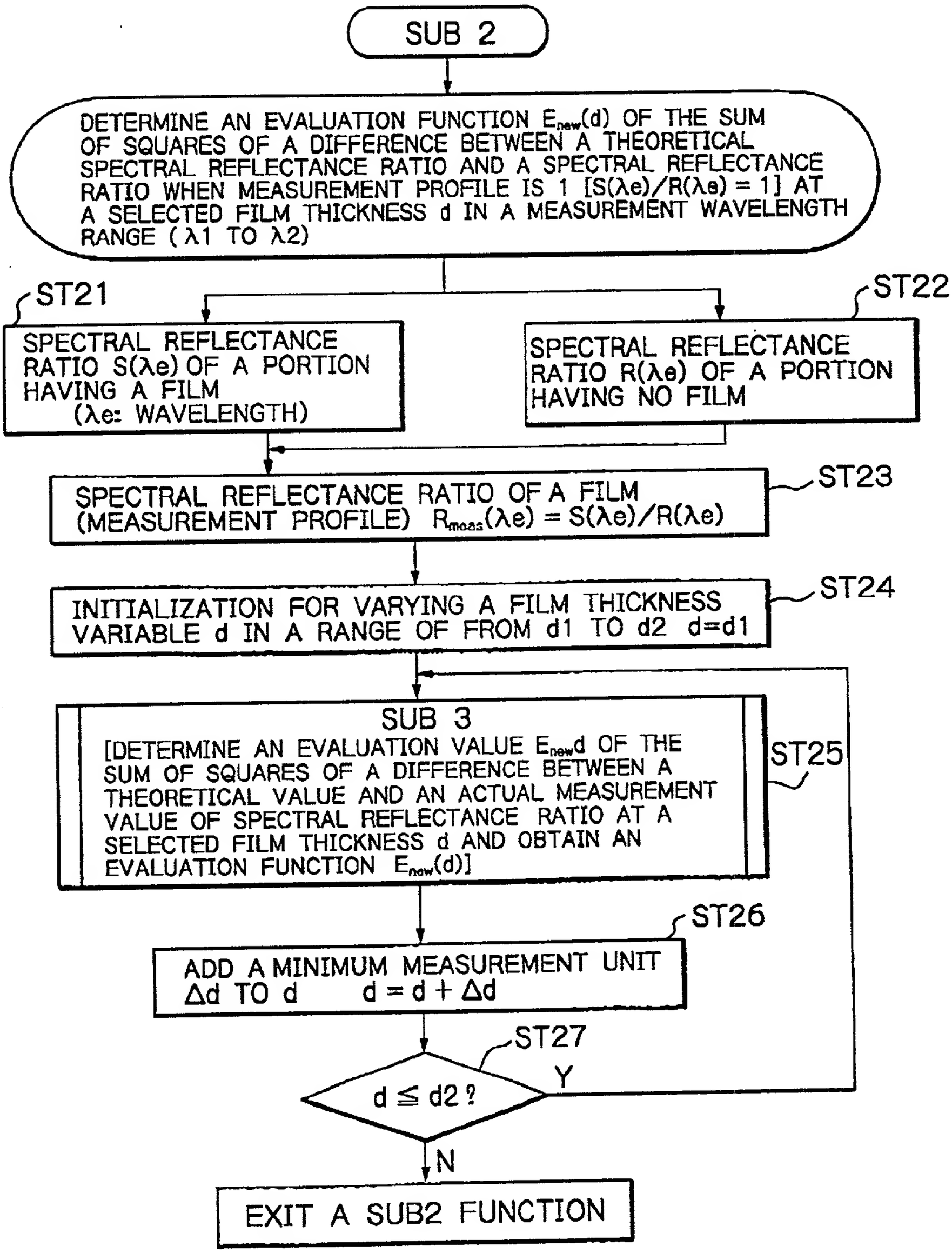
SUB 2
DETERMINE AN EVALUATION FUNCTION $E_{new}(d)$ OF THE SUM OF SQUARES OF A DIFFERENCE BETWEEN A THEORETICAL SPECTRAL REFLECTANCE RATIO AND A SPECTRAL REFLECTANCE RATIO WHEN MEASUREMENT PROFILE IS 1 [$S(\lambda e)/R(\lambda e) = 1$] AT A SELECTED FILM THICKNESS d IN A MEASUREMENT WAVELENGTH RANGE ($\lambda 1$ TO $\lambda 2$)
ST21
SPECTRAL REFLECTANCE RATIO $S(\lambda e)$ OF A PORTION HAVING A FILM (λe: WAVELENGTH)
ST22
SPECTRAL REFLECTANCE RATIO $R(\lambda e)$ OF A PORTION HAVING NO FILM
SPECTRAL REFLECTANCE RATIO OF A FILM (MEASUREMENT PROFILE) $R_{meas}(\lambda e) = S(\lambda e)/R(\lambda e)$
ST23
INITIALIZATION FOR VARYING A FILM THICKNESS VARIABLE d IN A RANGE OF FROM d1 TO d2 d=d1
ST24
SUB 3
[DETERMINE AN EVALUATION VALUE $E_{new}d$ OF THE SUM OF SQUARES OF A DIFFERENCE BETWEEN A THEORETICAL VALUE AND AN ACTUAL MEASUREMENT VALUE OF SPECTRAL REFLECTANCE RATIO AT A SELECTED FILM THICKNESS d AND OBTAIN AN EVALUATION FUNCTION $E_{new}(d)$]
ST25
ADD A MINIMUM MEASUREMENT UNIT Δd TO d $d = d + \Delta d$
ST26
$d \leqq d2$?
ST27
Y
N
EXIT A SUB2 FUNCTION

Fig. 8

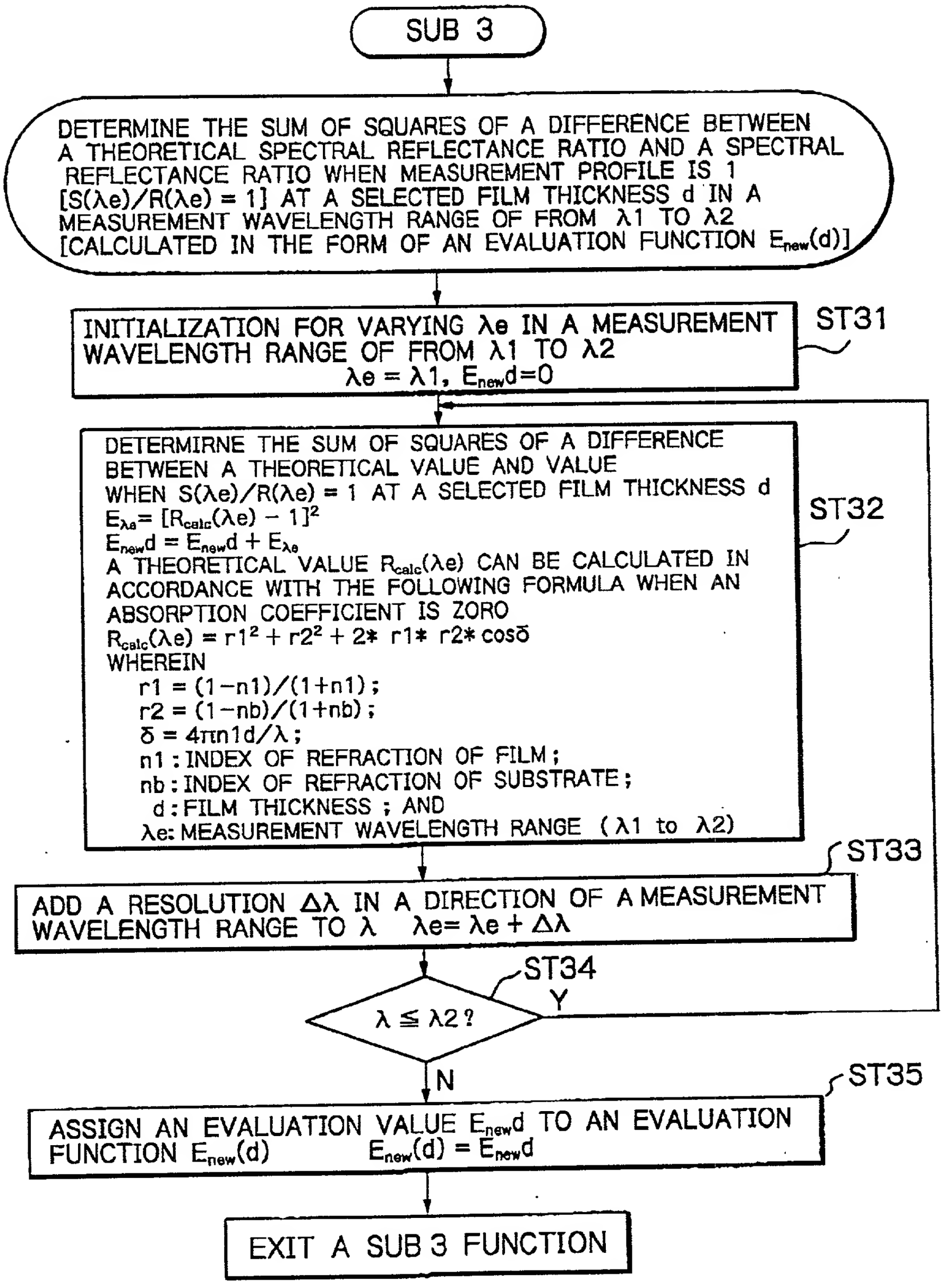
SUB 3
DETERMINE THE SUM OF SQUARES OF A DIFFERENCE BETWEEN A THEORETICAL SPECTRAL REFLECTANCE RATIO AND A SPECTRAL REFLECTANCE RATIO WHEN MEASUREMENT PROFILE IS 1 [S(λe)/R(λe) = 1] AT A SELECTED FILM THICKNESS d IN A MEASUREMENT WAVELENGTH RANGE OF FROM λ1 TO λ2 [CALCULATED IN THE FORM OF AN EVALUATION FUNCTION Enew(d)]
INITIALIZATION FOR VARYING λe IN A MEASUREMENT WAVELENGTH RANGE OF FROM λ1 TO λ2
λe = λ1, Enewd=0
ST31
DETERMIRNE THE SUM OF SQUARES OF A DIFFERENCE BETWEEN A THEORETICAL VALUE AND VALUE WHEN S(λe)/R(λe) = 1 AT A SELECTED FILM THICKNESS d
Eλe= [Rcalc(λe) − 1]2
Enewd = Enewd + Eλe
A THEORETICAL VALUE Rcalc(λe) CAN BE CALCULATED IN ACCORDANCE WITH THE FOLLOWING FORMULA WHEN AN ABSORPTION COEFFICIENT IS ZORO
Rcalc(λe) = r12 + r22 + 2* r1* r2* cosδ
WHEREIN
r1 = (1−n1)/(1+n1);
r2 = (1−nb)/(1+nb);
δ = 4πn1d/λ;
n1 : INDEX OF REFRACTION OF FILM;
nb : INDEX OF REFRACTION OF SUBSTRATE;
d : FILM THICKNESS ; AND
λe: MEASUREMENT WAVELENGTH RANGE (λ1 to λ2)
ST32
ADD A RESOLUTION Δλ IN A DIRECTION OF A MEASUREMENT WAVELENGTH RANGE TO λ λe= λe + Δλ
ST33
λ ≦ λ2 ?
ST34
Y
N
ASSIGN AN EVALUATION VALUE Enewd TO AN EVALUATION FUNCTION Enew(d) Enew(d) = Enewd
ST35
EXIT A SUB 3 FUNCTION

Fig. 9

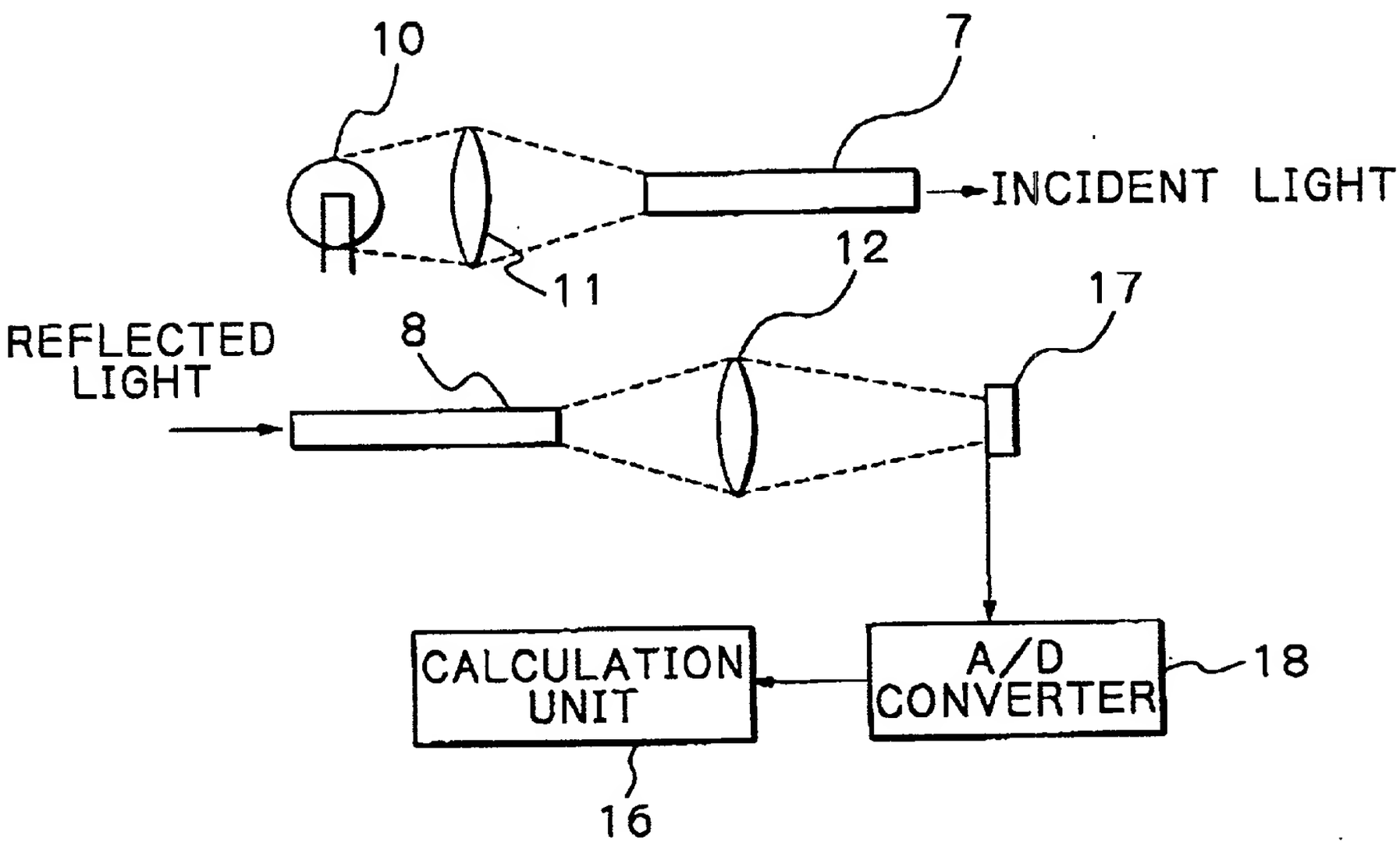
10
7
INCIDENT LIGHT
12
11
17
REFLECTED LIGHT
8
CALCULATION UNIT
A/D CONVERTER
18
16

Fig. 10

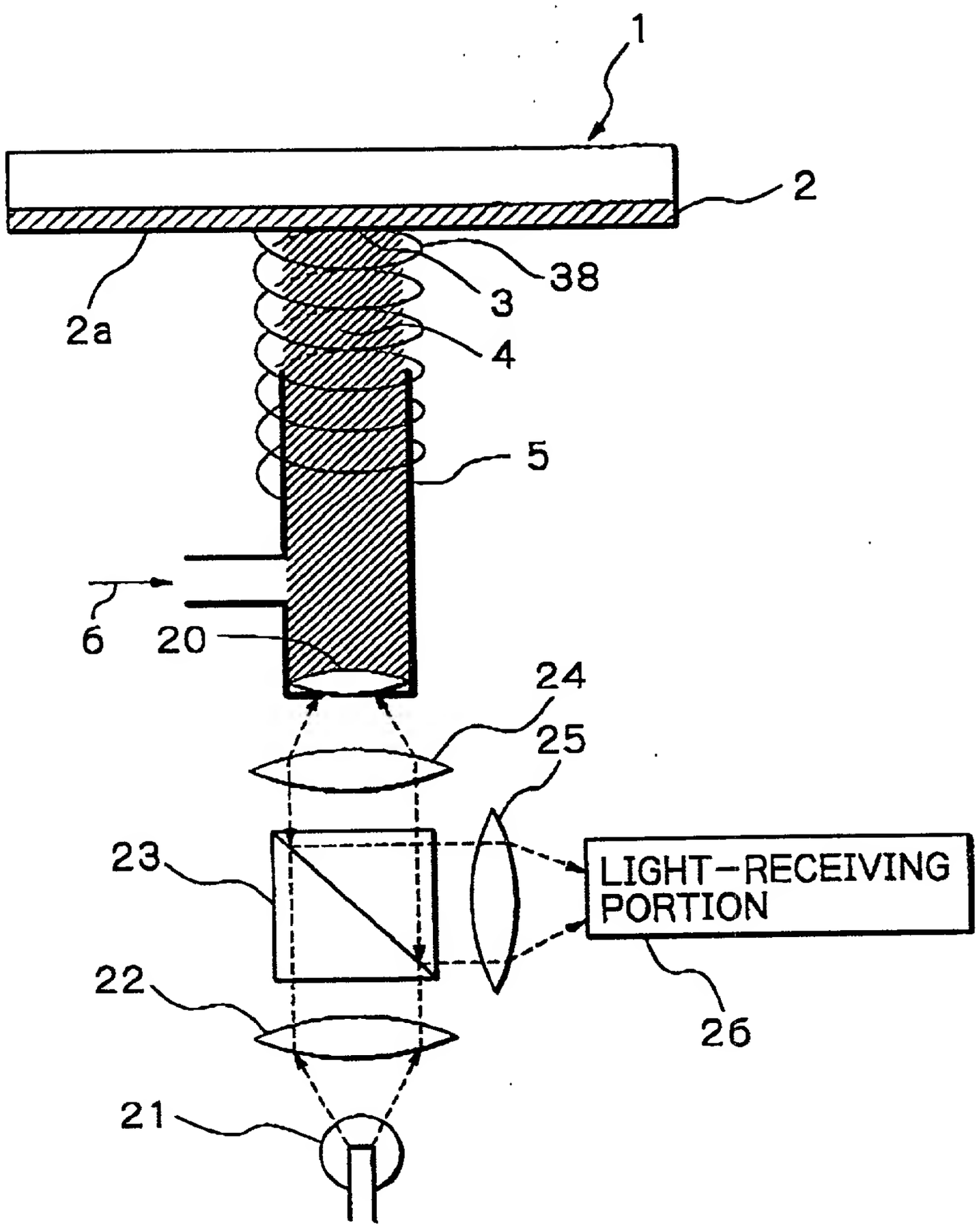

Fig. 11

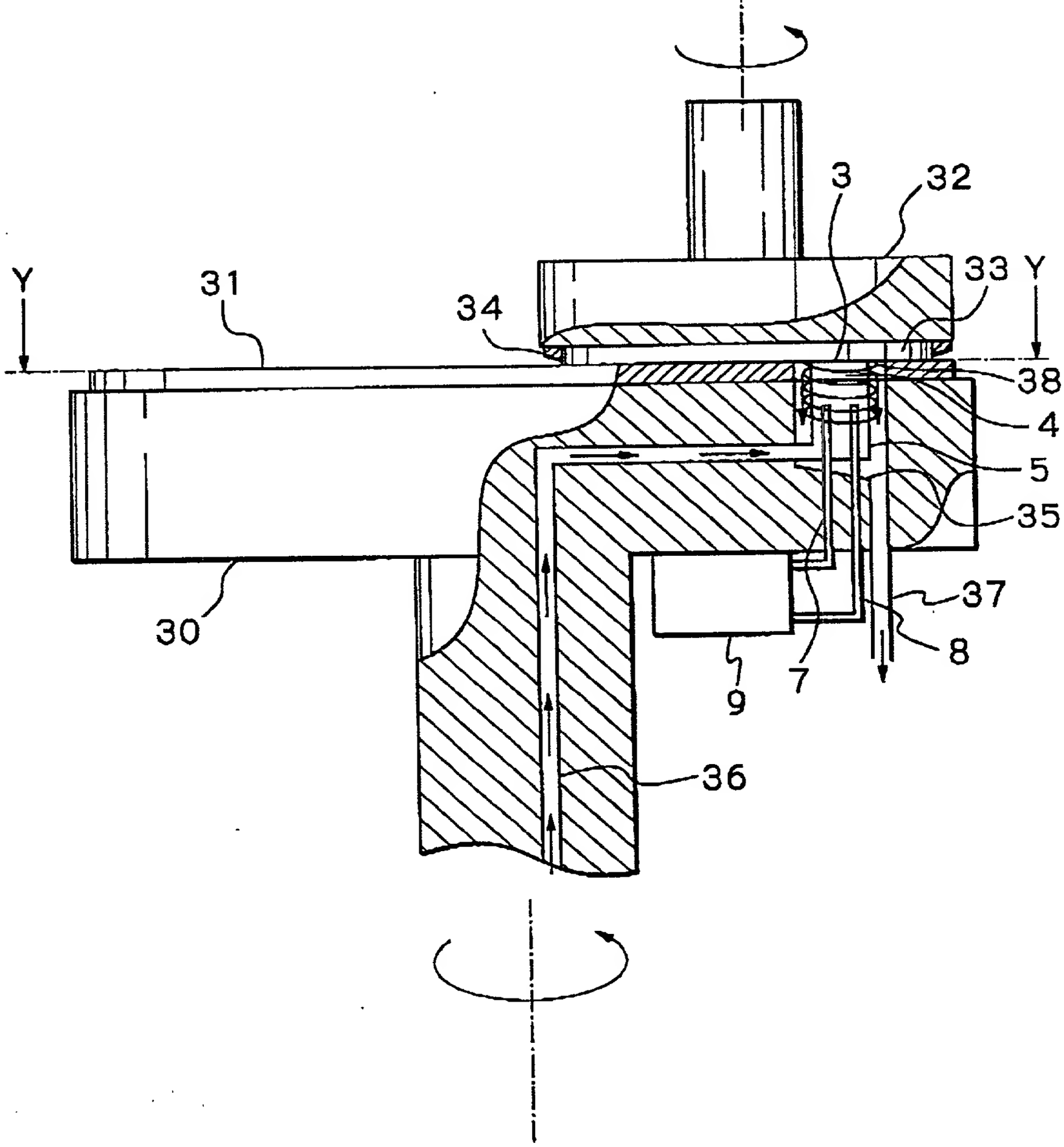

Fig. 12

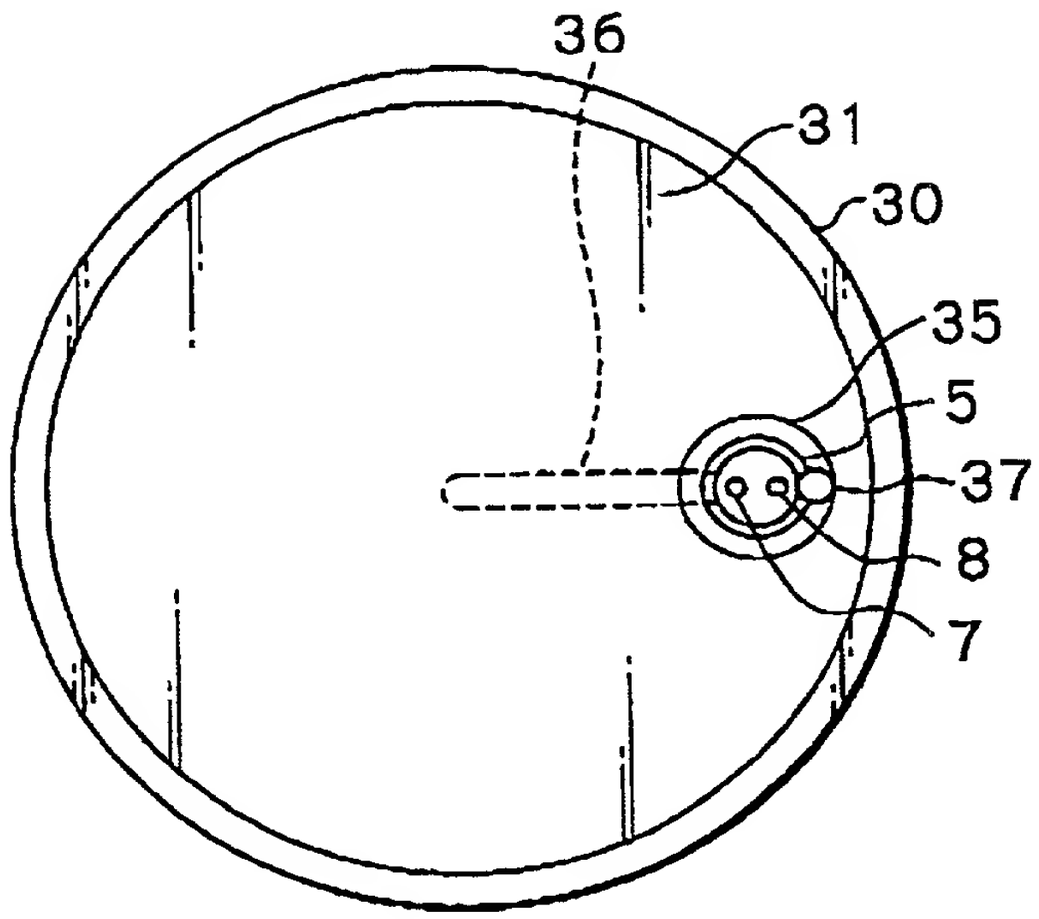

Fig. 13

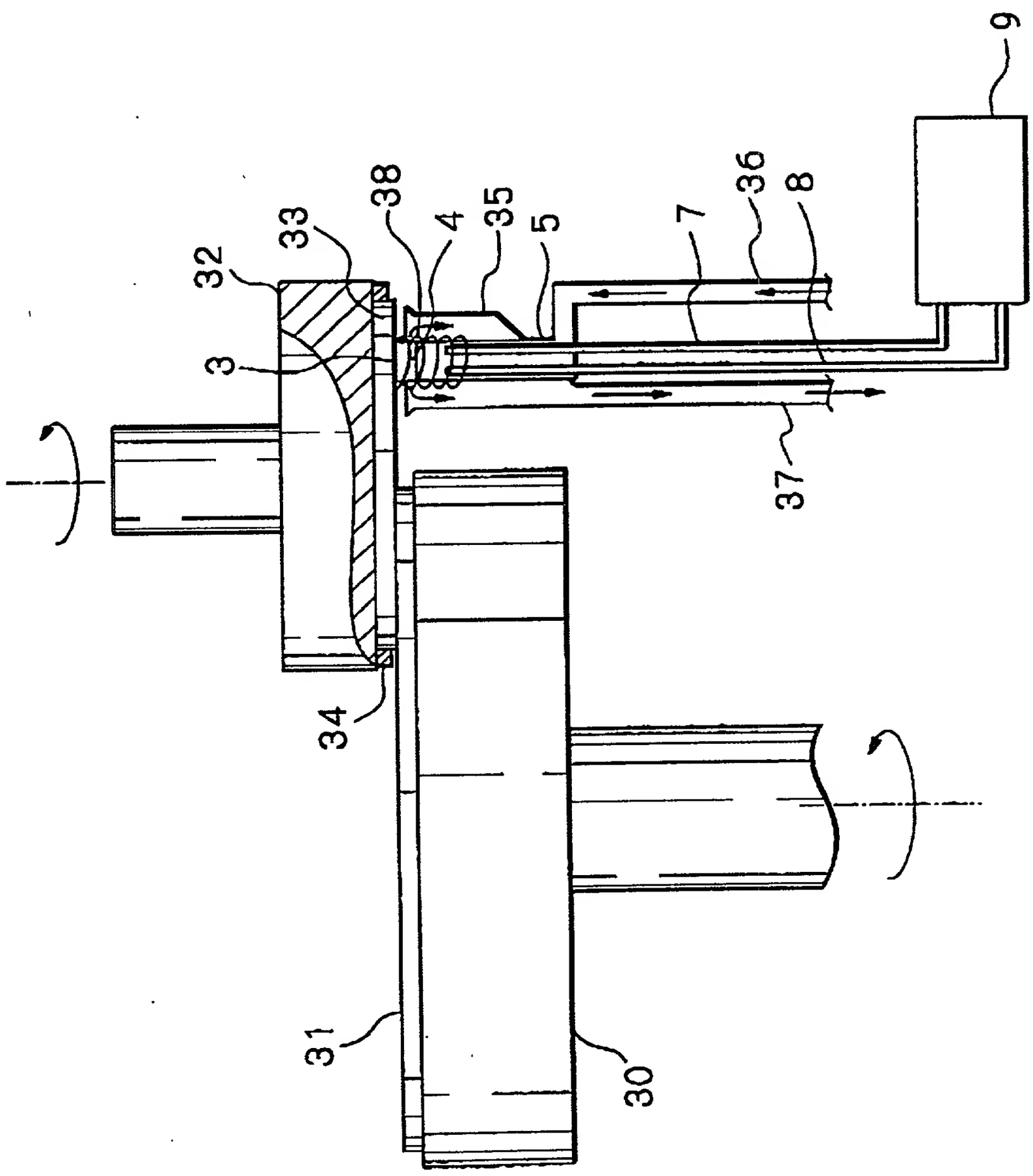

Fig. 14

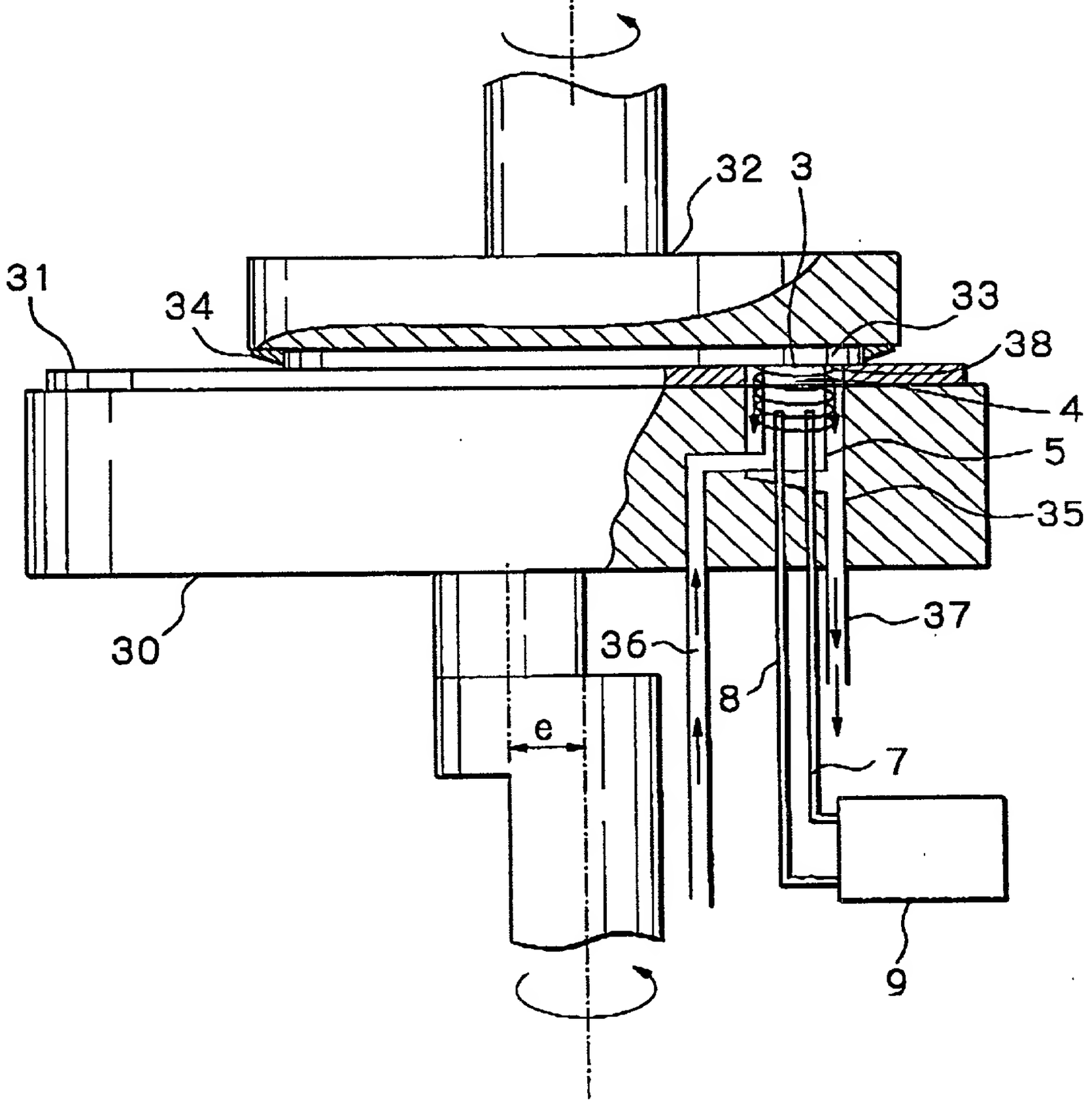

Fig. 15

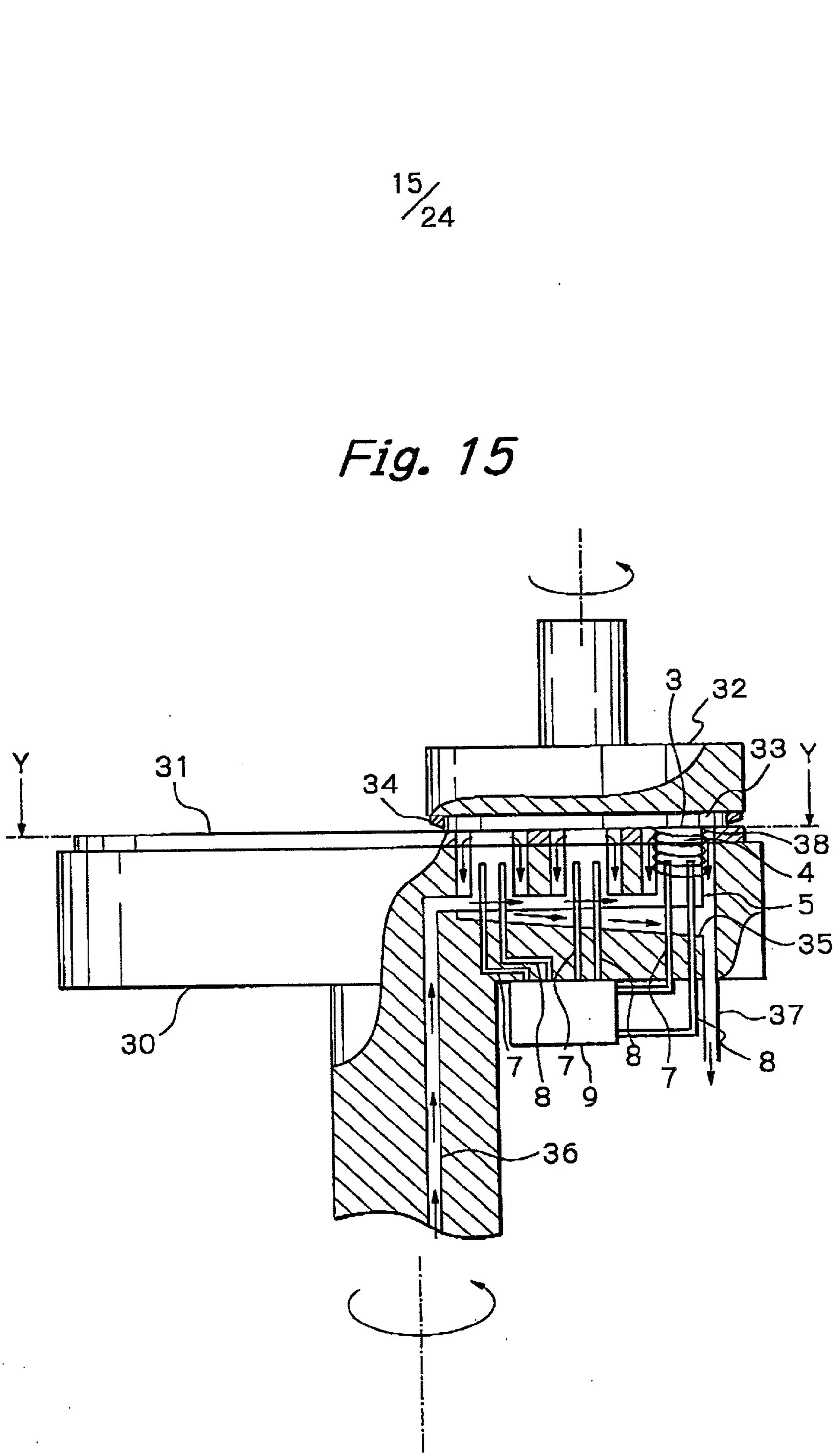

Fig. 16

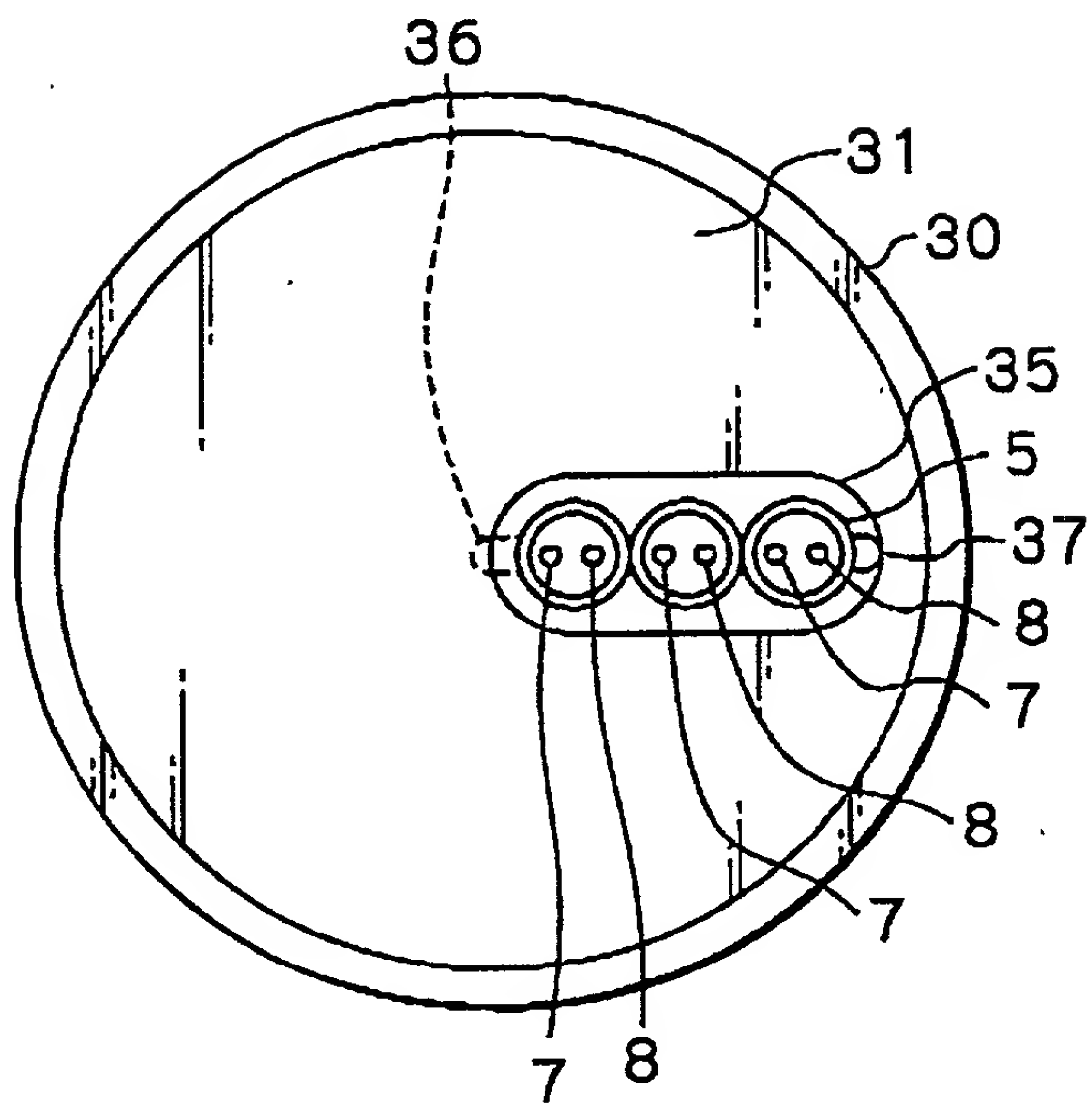

Fig. 17

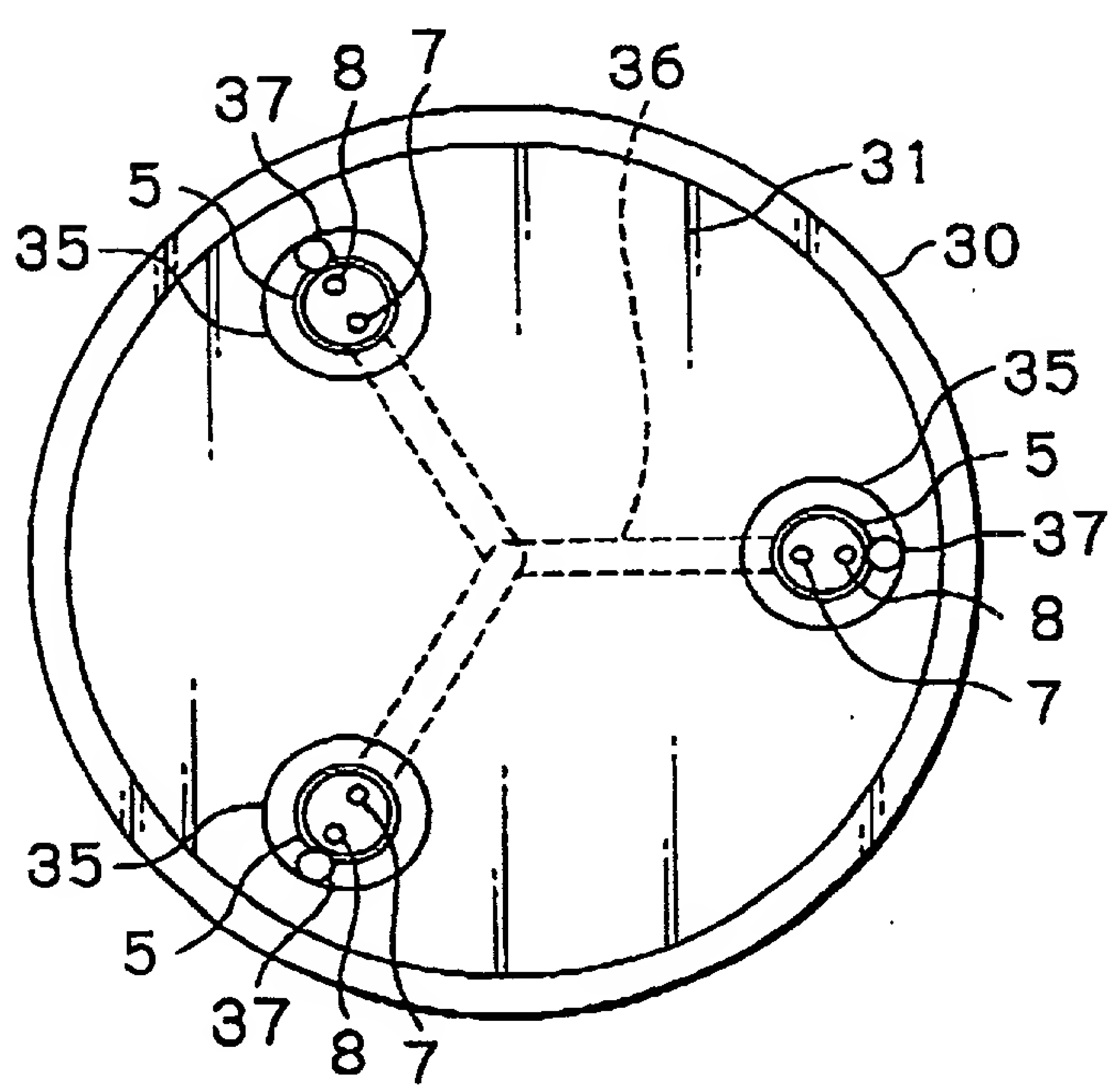

Fig. 18

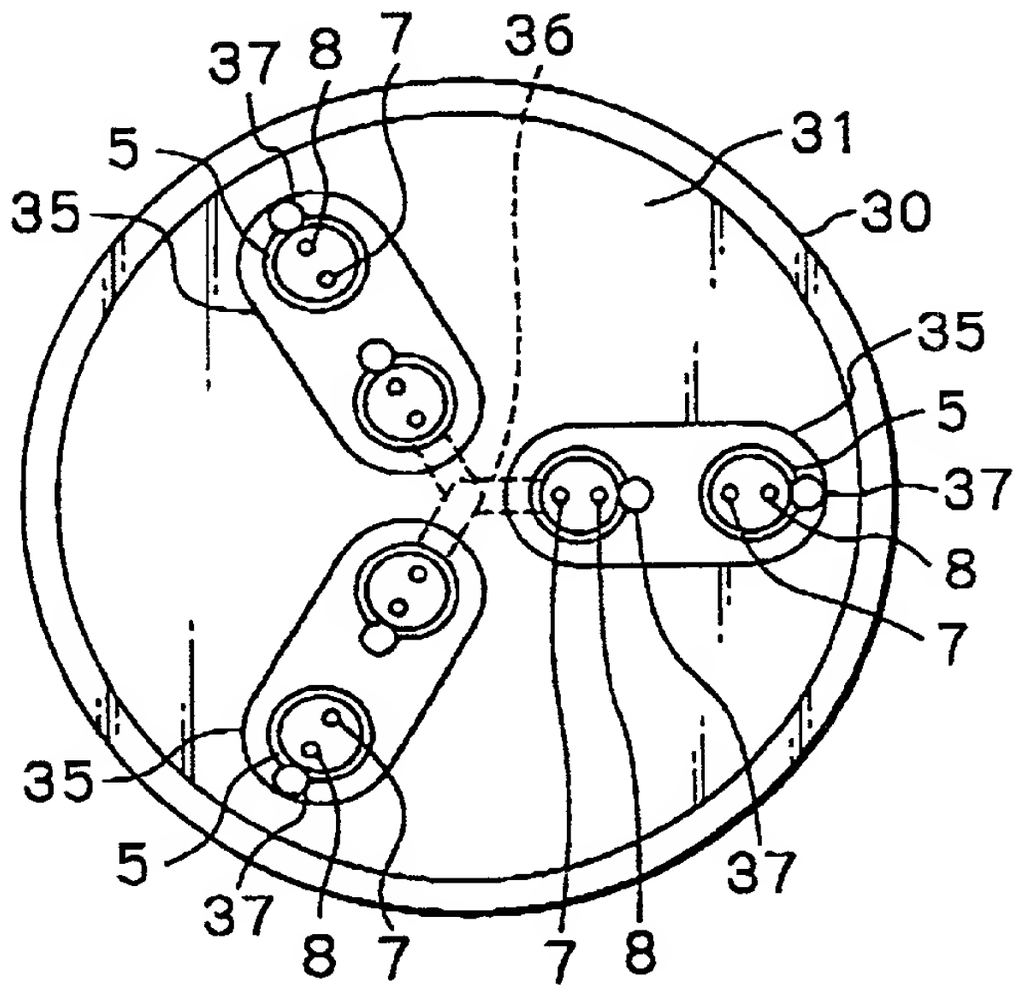

Fig. 19

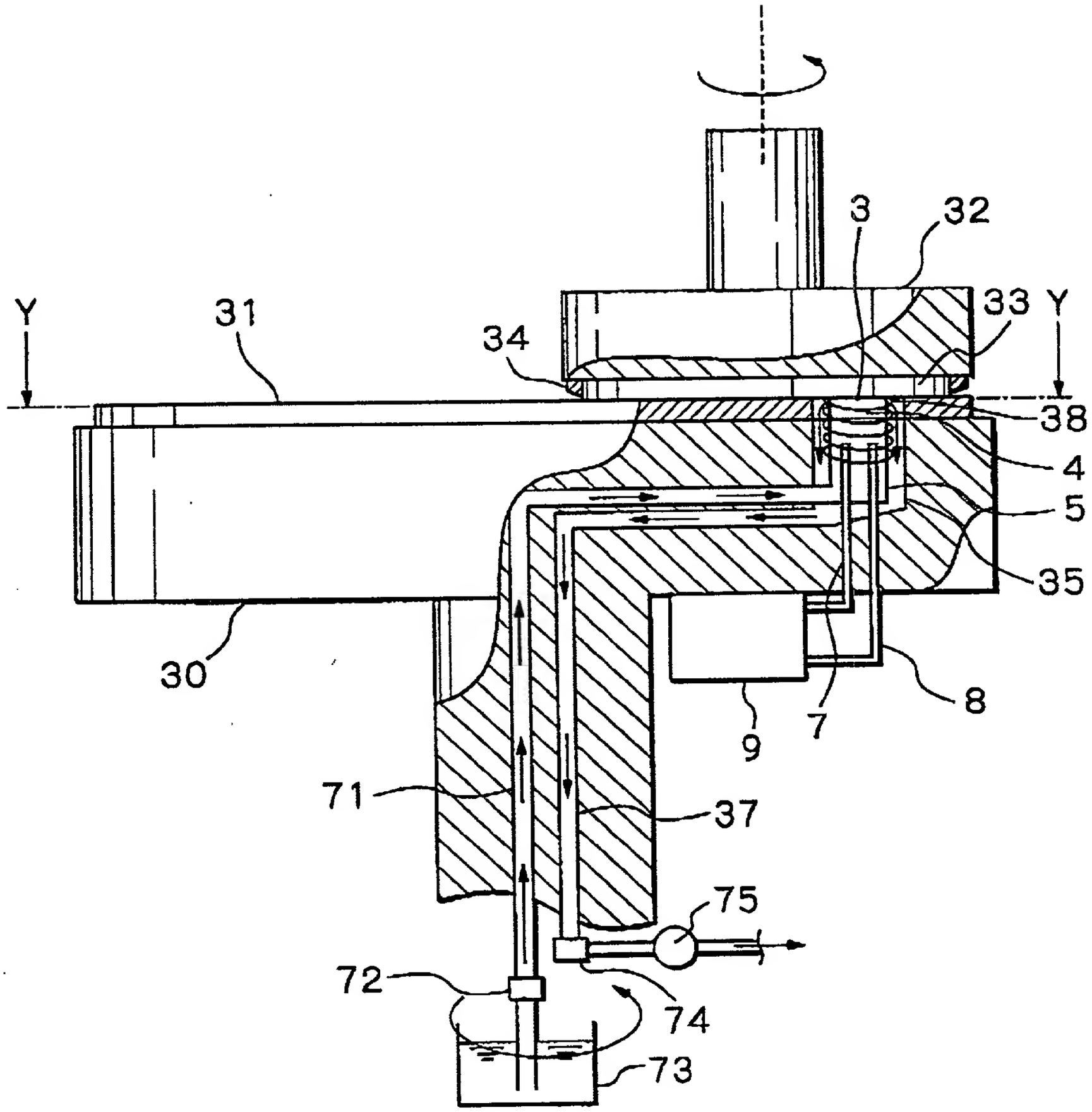

Fig. 20

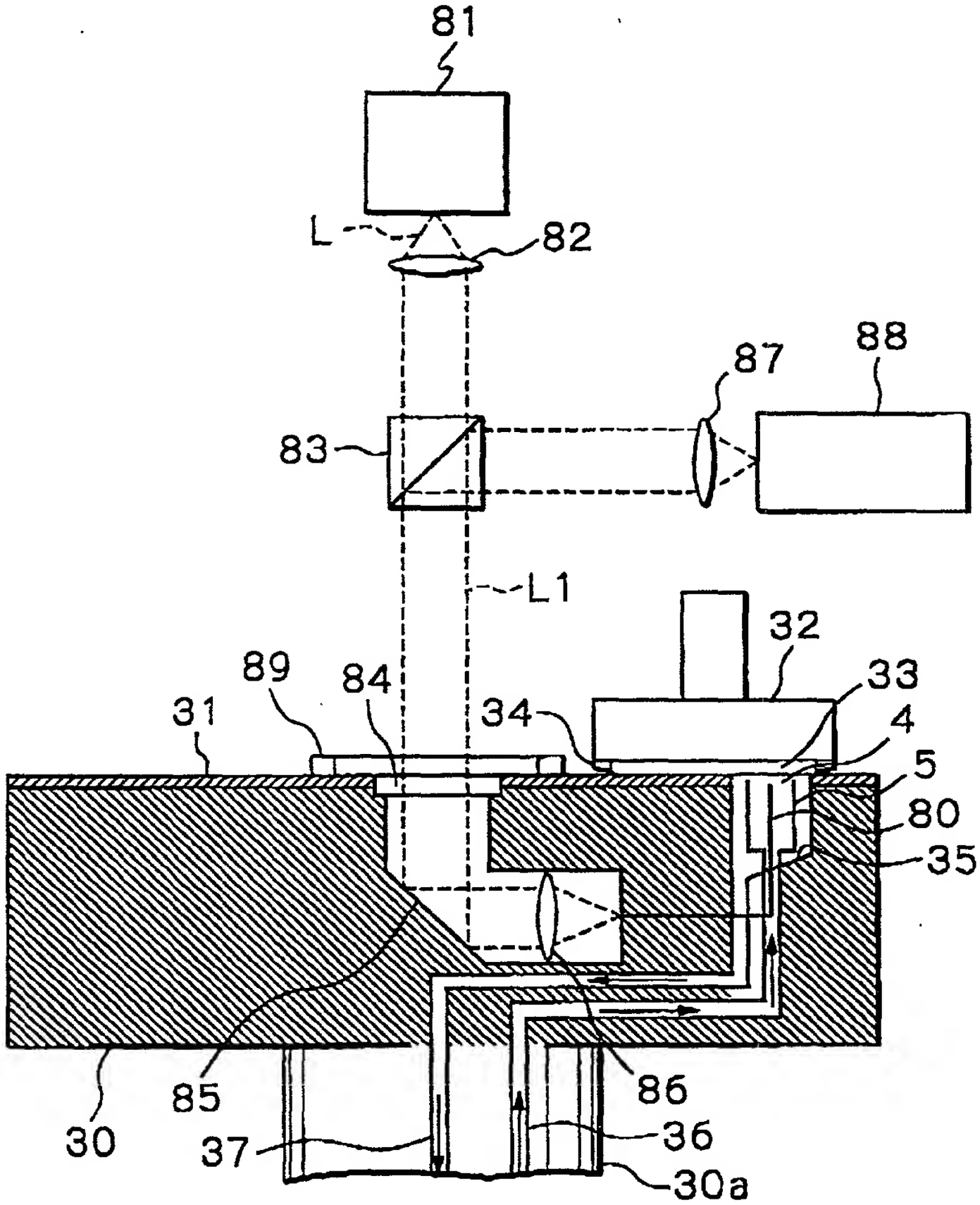

Fig. 21

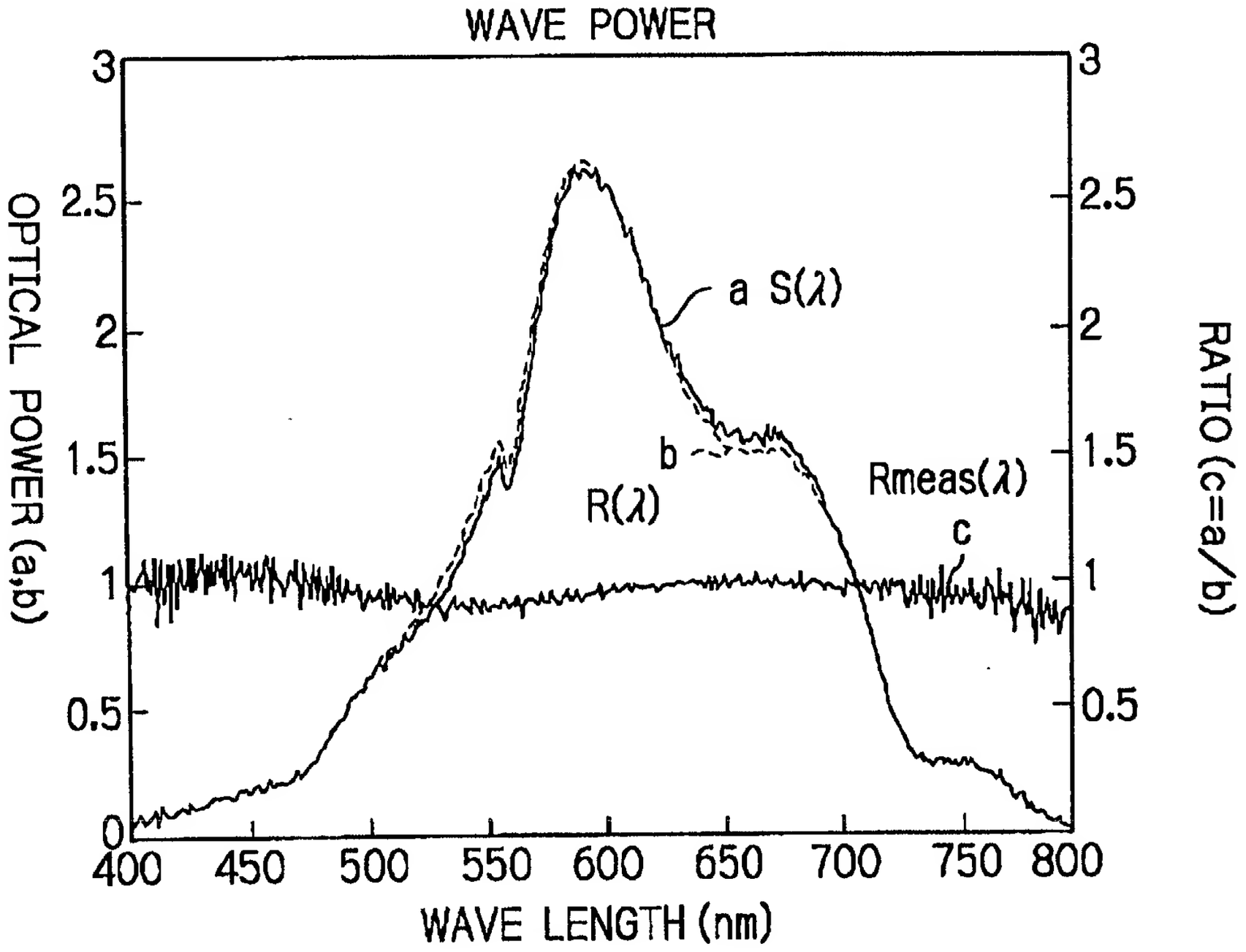
WAVE POWER
OPTICAL POWER (a,b)
RATIO (c=a/b)
a S(λ)
b
R(λ)
Rmeas(λ)
c
3
2.5
2
1.5
1
0.5
0
400
450
500
550
600
650
700
750
800
WAVE LENGTH (nm)

Fig. 22

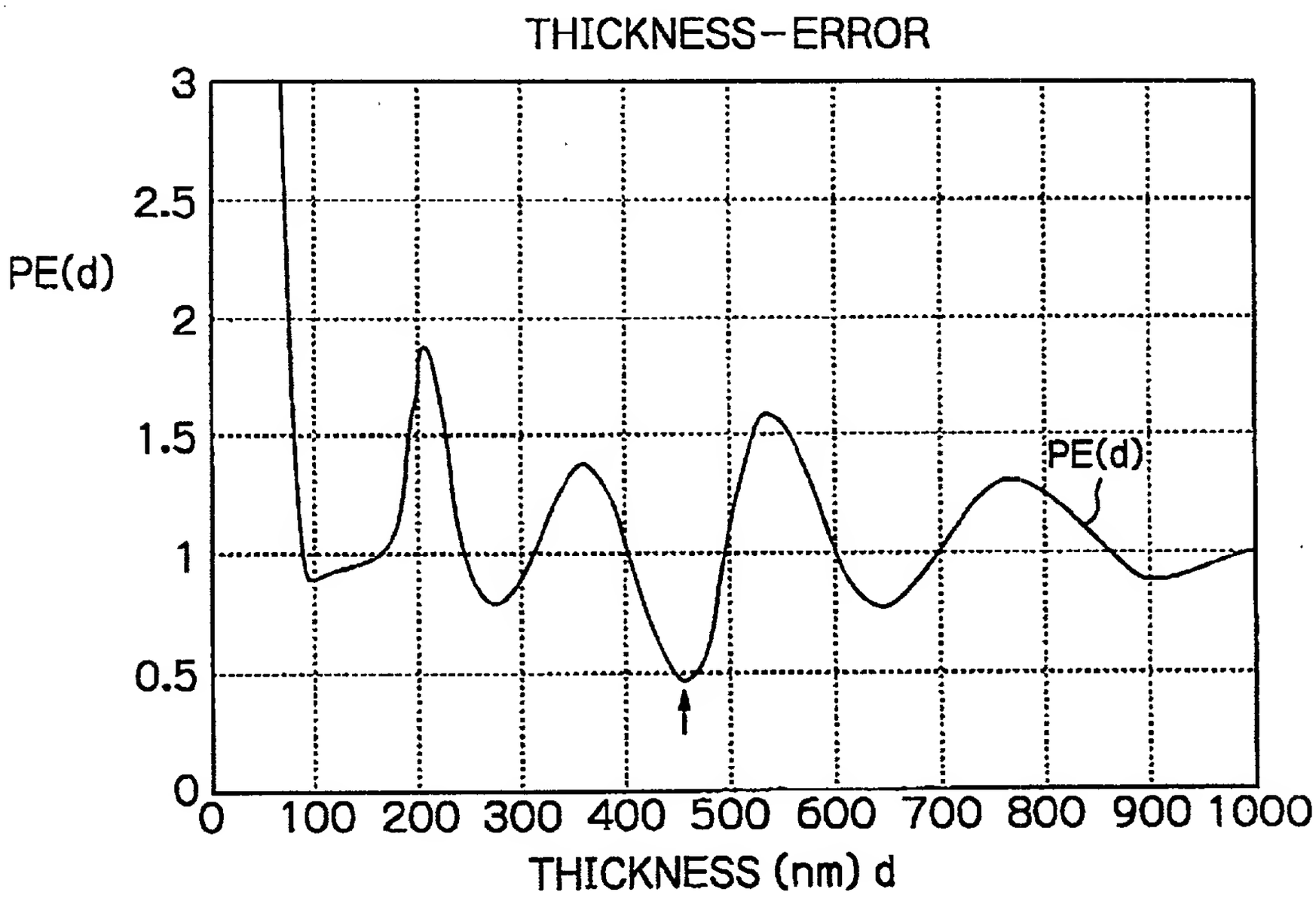
THICKNESS-ERROR
PE(d)
3
2.5
2
1.5
1
0.5
0
0
100
200
300
400
500
600
700
800
900
1000
PE(d)
THICKNESS (nm) d

Fig. 23

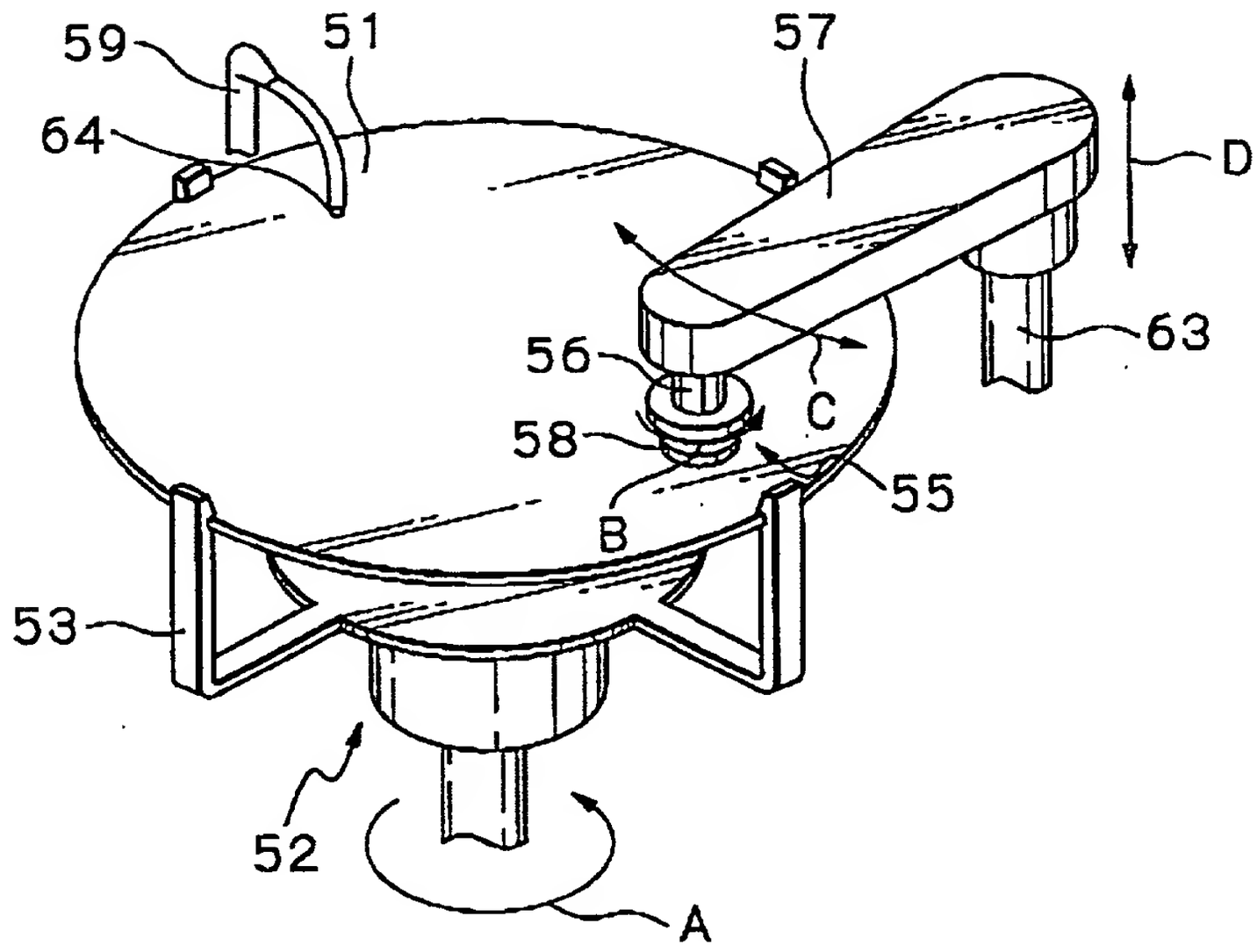

Fig. 24

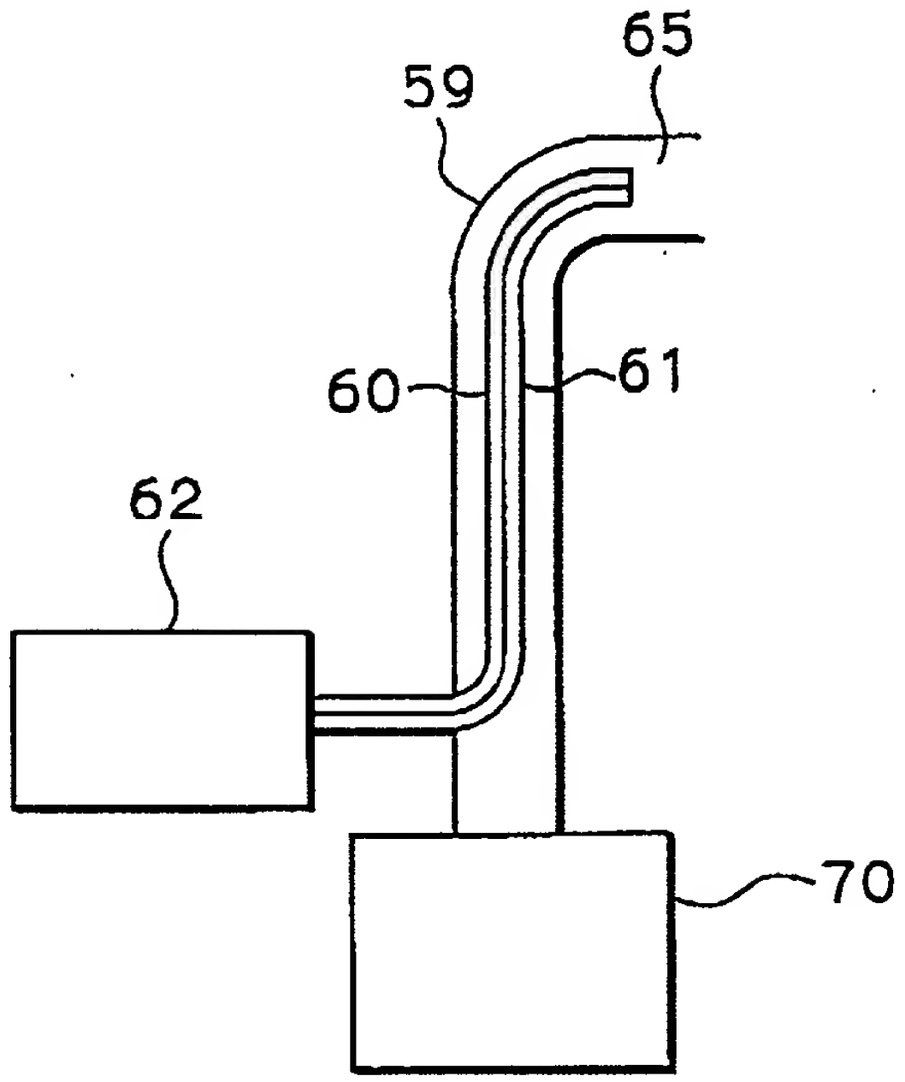

Fig. 25

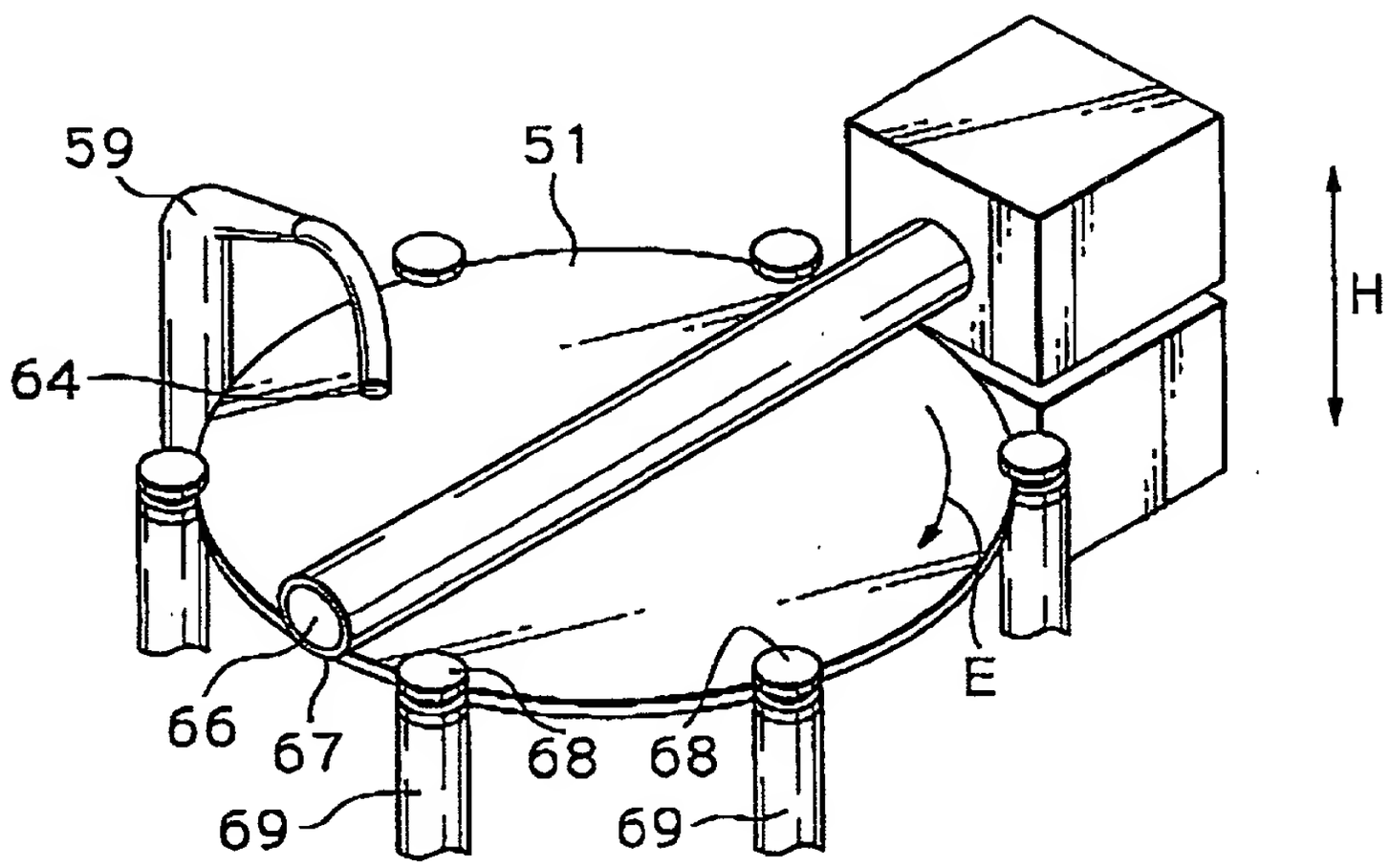

Fig. 26